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ORIGINAL ARTICLE

Percutaneous hallux valgus correction using the Reverdin-Isham osteotomy

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KEYWORDS

Hallux valgus deformity;
Percutaneous surgery;
Metatarsal osteotomy;
Reverdin-Isham osteotomy

Summary

Introduction: The present study assessed 2-year clinical and radiological results of percutaneous correction of hallux valgus by Reverdin-Isham osteotomy and sought to clarify indications for the technique.

Patient and methods: A continuous prospective single-center series of 104 cases of medium-to-moderate hallux valgus was managed by the same percutaneous technique, with a median 2 years' clinical and radiological follow-up (with no loss to follow-up). Uni- and multivariate analysis determined predictive factors for the mobility and degree of correction obtained.

Results: American Orthopedic Foot and Ankle Society (AOFAS) functional score rose from a preoperative median of 49/100 to 87.5/100 postoperatively ($p < 0.05$); 89% of patients were satisfied or very satisfied with their result at end of follow-up. Hallux valgus and distal metatarsal articular angle (DMAA) were significantly reduced (30 and 15° to 15 and 7°, respectively; $p < 0.05$). Associated lateral ray surgery significantly increased the postoperative risk of MTP1 joint incongruence ($p = 0.009$).

Discussion: Percutaneous correction by Reverdin-Isham osteotomy seemed effective in isolated medium-to-moderate hallux valgus, but involves a learning curve and lacks precision in case of associated lateral metatarsal osteotomy, with a risk of DMAA hypercorrection and increased risk of MTP1 joint incongruence. Indications for percutaneous Reverdin-Isham osteotomy seem to be limited to isolated medium-to-moderate hallux valgus (M1M2 angle $< 15^\circ$, M1P1 angle around 30°) with elevated DMAA and congruent MTP1 joint.

Level of evidence: Level IV. Therapeutic study.

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Introduction

Hallux valgus is a frequent deformity of the first-ray of the forefoot, progressively and to varying degrees associating first-phalanx abduction and pronation, first-metatarsal

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adduction, pronation and elevation and lateral capsuloligamentary retraction of the first-ray metatarsophalangeal (MTP1) joint [1–3]. Surgical correction is indicated for pain and difficulty with footwear. Many procedures have been described and notably a variety of first-metatarsal osteotomy procedures [3–9].

Distal metatarsal osteotomy is recommended to correct mild-to-moderate deformity with intermetatarsal angle not exceeding 15° or to correct the distal metatarsal articular angle (DMAA) [10,11]. Minimally invasive or percutaneous designs have been described for distal first-metatarsal osteotomy, with or without osteosynthesis [11–15]. Reverdin's osteotomy, revised by Isham, is a percutaneous procedure without osteosynthesis, to align the first-ray by medial rotation of the first-metatarsal head and DMAA correction [12]. The interest of a percutaneous technique lies in the reduced morbidity and surgery time, theoretically shortening recovery time. Its vagaries concern the quality of correction and long-term stability.

The present study assessed 2-year clinical and radiological results of percutaneous correction of hallux valgus by Reverdin-Isham osteotomy and analyzed prognostic factors of failure, so as to clarify indications for the technique.

Patient and methods

Description of study

A continuous prospective single-center, single-surgeon series of 104 cases of hallux valgus was managed by the same percutaneous technique, in 82 patients, between September 2004 and June 2006. Surgery was indicated for painful hallux valgus with functional impact and difficulty with footwear. A percutaneous design was indicated for mild-to-moderate deformity: hallux valgus angle (M1P1 angle) up to 40° and intermetatarsal angle (M1M2 angle) up to 15° . Some patients presenting with M1P1 $>40^\circ$ but M1M2 $<15^\circ$ were also included, as were others with M1M2 $>15^\circ$ but M1P1 $<40^\circ$. Median age was 57 years (range, 23 to 87 years); there were 76 women and six men. There were 33 right feet, 27 left, and 22 one-step bilateral operations.

Surgical technique

All patients were operated on under locoregional anesthesia (perimetatarsal conduction block), and 77 in ambulatory surgery. All underwent the same first-ray procedure performed by the same surgeon, following Isham [12] and De Prado et al. [16]. The patient was installed in supine position, with a tourniquet above the malleoli, inflated to 250 mmHg. A 3–5 mm incision in the medial and plantar edge of the first-metatarsal head was followed by capsule detachment to obtain a work-space. First, the medial and dorsal protrusion of the first-metatarsal head was resected by conical burr on a drill with torque multiplication, operating at low speed (max.: 5000 rpm) to avoid burning and bone and skin necrosis (Fig. 1). Bone resection was pursued under fluoroscopy up to the functional joint surface of the first-metatarsal head, outside the medial sagittal groove. Bone fragments were evacuated under manual pressure, with saline lavage and cleansing by rasps



Figure 1 Bone resection by motorized burr, with medial approach.

in the work-space. In the second stage, first-metatarsal Reverdin-Isham osteotomy was performed using a straight burr with the same medial approach. The medial closed wedge osteotomy of the first-metatarsal distal metaphysis, parallel to the joint surface, was carried out from distal dorsal, just behind the joint space, to proximal plantar, behind the sesamoids, with a slope of 45° (Fig. 2). The lateral cortex was conserved. The hallux was then put in forced adduction, enabling compression by osteoclasia, medial closure of the Reverdin-Isham osteotomy and DMAA correction (Fig. 3). In the third step, lateral capsuloligamentary release of the metatarsophalangeal joint was associated with transverse abductor tenotomy by Beaver® blade with a second dorsolateral approach facing the metatarsophalangeal joint-line. The final step comprised varization osteotomy of the first-phalanx, with a third, dorsomedial, approach of 3 mm medially to the extensor hallucis longus tendon. A short straight burr was used for proximal metaphyseal osteotomy of the phalanx, under fluoroscopy, conserving the lateral cortex. Correction was obtained by medial closure of the osteotomy with the hallux in forced varus (Fig. 4). No osteosynthesis was performed. Postoperative dressing in slight hypercorrection for 10 days maintained the correction and kept the osteotomies closed, and was then changed for a dressing with a cohesive bandage with an orthoplasty maintaining first-ray alignment for 1 month (Fig. 5). Complete weight-bearing was resumed immediately, with a

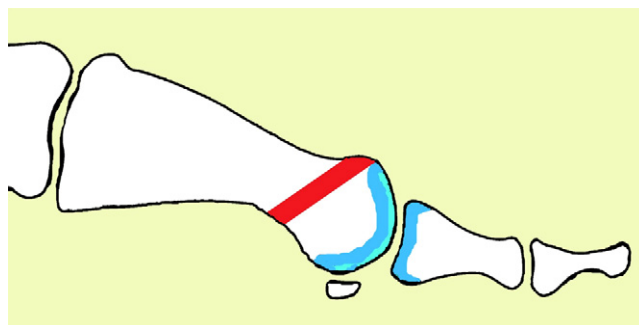


Figure 2 Reverdin-Isham osteotomy (AP view).

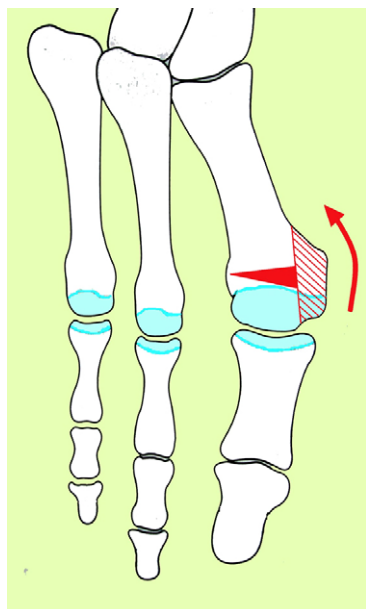


Figure 3 Reverdin-Isham osteotomy (AP view). Correction is obtained by medial rotation (closure of metatarsal osteotomy, distal metatarsal articular angle [DMAA] correction).

rigid flat-soled orthopedic shoe for the first month. Preventive anticoagulants were not prescribed except in case of history of deep venous thrombosis or risk factors (coagulation disorder, thrombopathy). Metatarsophalangeal joint mobilization was authorized after the first dressing was put on.

In 39% of cases ($n=41$), osteotomy of the lateral metatarsals was performed in the same surgical step. These were all patients presenting with lateral ray metatarsalgia associated with the first-ray deformity. In all cases, percutaneous first-, third- and fourth-ray distal metatarsal osteotomy was performed. In case of associated claw-toe,



Figure 4 Percutaneous first-phalanx varization osteotomy.



Figure 5 Postoperative orthoplasty (as of day 10).

percutaneous surgery was performed in the same step, associating dorsal metatarsophalangeal arthrolysis, extensor and flexor tenotomy, P1 osteotomy and arthroplastic resection of the proximal interphalangeal joint, depending on the severity and reducibility of the deformity.

Assessment

Clinical

Pre- and postoperative functional American Orthopedic Foot and Ankle Society (AOFAS) scores (the AOFAS hallux-metatarso-phalangeal-interphalangeal scale) was calculated in all cases [17]. Passive MTP1 joint mobility (sum of dorsi- and plantar flexion) was measured by manual goniometry with the patient in dorsal decubitus, ankle in neutral position and knee in extension. Other parameters were also noted: forefoot digital formula (Greek, square or Egyptian), time to resumption of normal footwear, and presence of postoperative edema. Patient satisfaction (very satisfied, satisfied, dissatisfied or disappointed) was also rated at end of follow-up.

Radiological

Anteroposterior (AP) weight-bearing views were taken pre-operatively and at end of follow-up, in all cases. Several manual measurements were made on each image, by a single observer: hallux valgus angle (M1P1 angle), metatarsus varus angle (M1M2 angle), first-metatarsal distal joint surface orientation angle (DMAA), first-ray shortening (metatarsus and phalanx), and metatarsal index (index plus, index plus-minus, index minus). MTP1 joint congruency was assessed on Pigott's criteria (centered congruent joint, deviated or subluxated non-congruent joint) [2]. MTP1 joint arthritis was assessed on Coughlin and Shurnas's criteria (Table 1) [18].

Table 1 Radiographic signs of first-ray metatarsophalangeal (MTP1) joint arthritis (Coughlin and Shurnas [18]).

Grade 0	Normal or subnormal joint
Grade 1	Osteocondensation, joint space narrowing (<50%), dorsal osteophytosis, slight flattening of M1 head
Grade 2	Overall joint space narrowing (>50%), osteocondensation, circumferential osteophytosis, irregular sesamoids aspect
Grade 3	Abnormalities as in grade 2, but with almost total joint space narrowing and presence of cysts
Grade 4	Disappearance of MTP1 joint space

Statistical analysis

Quantitative variables were expressed as median and interquartile range (IQR), unless stated otherwise. Qualitative variables were expressed as numbers and percentages. Stepwise descending multiple regression models, based on Akaike's Information Criterion (AIC) [19] were used to predict: M1P1 angle, M1M2 angle, DMAA, and postoperative dorsiflexion and joint congruence. The following dependent variables showing sufficient influence ($p < 0.2$) on univariate analysis were included in the multivariate model: preoperative M1P1 angle, preoperative M1M2 angle, preoperative DMAA, percutaneous lateral metatarsal osteotomy, and MTO1 arthritis (as seen from MTP1 joint-line pinching on preoperative AP X-ray). Analysis used R software [20]. All tests were bilateral; the significance threshold was set at 0.05.

Table 2 Results for series.

Data	Preoperative	Postoperative	
<i>AOFAS score</i>			
Global score	49 (44–52)	87.5 (67–93.5)	<0.05
Pain	20 (20–20)	40 (30–40)	<0.05
Function	29 (24–37)	45 (40–45)	<0.05
Alignment	0 (0–0)	15 (15–15)	<0.05
<i>MTP1 mobility</i>			
Global mobility	95 (60–100)	80 (55–100)	NS
Dorsiflexion	80 (70–90)	70 (60–80)	NS
Plantar flexion	15 (10–20)	10 (10–20)	NS
<i>Forefoot morphotype</i>			
Greek	26 (25%)	33 (32%)	NS
Square	31 (30%)	46 (44%)	NS
Egyptian	47 (45%)	25 (24%)	NS
<i>Angles</i>			
M1P1	30 (25–32)	15 (11–18)	<0.05
M1M2	14 (12–15)	11 (9–13)	NS
DMAA	15 (12–18)	7 (4–10)	<0.05
<i>Metatarsal index</i>			
Minus	70 (67%)	73 (70%)	NS
Plus-minus	24 (23%)	26 (25%)	NS
Plus	10 (10%)	5 (5%)	NS
<i>MTP1 non-congruent</i>	31 (30%)	34 (33%)	NS

Quantitative variables: median with interquartile range (IQR); qualitative variables: absolute value with percentage (%); mobility: degrees.

Results

All patients were followed up for at least 12 months, with a mean follow-up (FU) of 24 months (range: 12–40 months). None were lost to follow-up (Table 2, Fig. 6a and b).

**Figure 6** a: isolated hallux valgus: preoperative clinical and radiologic aspect; b: clinical and radiologic control at 18 months.

Complications

Complications included four M1 and five P1 lateral cortex fractures, not requiring revision. There were six cases of DMAA hypercorrection (DMAA < 0°). Two patients showed severe painful MTP1 joint stiffness (global mobility < 30°), and two others showed complex regional pain syndrome. Three patients (3%) showed recurrence of deformity (M1P1 angle > 20°); there were no cases of hallux varus. Two patients showed transfer metatarsalgia 18 months after percutaneous correction of isolated hallux valgus.

Subjective and functional results

AOFAS functional score improved significantly, from a preoperative median of 49/100 (IQR: 44–52) to 87.5/100 postoperatively (IQR: 67–93.5) ($p < 0.05$). All items in the global AOFAS score (pain, function, alignment) showed significant improvement. Eighty-nine percent of patients were satisfied or very satisfied with their result at end of follow-up. Normal footwear was resumed at a mean 5 weeks (range: 10 days to 3 months) after percutaneous correction of isolated hallux valgus, and a mean 8 weeks (range: 3 weeks to 6 months) in case of associated lateral metatarsal osteotomy.

Clinical results

At 1 month postoperatively, edema was observed in 10% of patients in case of correction of isolated hallux valgus and in 82% in case of associated lateral metatarsal osteotomy ($p < 0.01$). Median MTP1 joint mobility was 95° (IQR: 60–100) preoperatively (median = 80° [IQR: 70–90] in dorsiflexion and 15° [IQR: 10–20] in plantar flexion) and 80° (IQR: 55–100) postoperatively (median = 70° [IQR: 60–80] in dorsiflexion and 10° [IQR: 10–20] in plantar flexion) (NS).

Radiographic results

Radiographic analysis found a significant reduction in hallux valgus, with a median MTP1 angle of 30° (IQR: 25–32) preoperatively and of 15° (IQR: 11–18) postoperatively ($p < 0.05$). The median intermetatarsal M1M2 angle decreased from 14° (IQR: 12–15) preoperatively to 11° (IQR: 9–13) postoperatively (NS). The DMAA decreased from 15° (IQR: 12–18) preoperatively to 7° (IQR: 4–10) postoperatively ($p < 0.05$). DMAA values (on weight-bearing AP view) showed great variation, with a preoperative range from 8° to 25° (i.e., 17°) and a postoperative range from –5 to 15° (i.e., 20°). The MTP1 joint was non-congruent in 31 cases (30%) preoperatively and in 34 (33%) postoperatively (NS). Mean first-metatarsal shortening was 4 mm (range: 0–9 mm) and mean first-phalanx shortening was 3 mm (range: 0–6 mm). No failures of metatarsal or phalangeal osteotomy consolidation were observed. No radiologic progression of arthritis was observed at end of follow-up.



Figure 7 a: hallux valgus and metatarsalgia: preoperative radiologic aspect; b: radiologic control at 1 year: consolidation of lateral ray distal metatarsal osteotomies, resolution of metatarsalgia. Recurrence of deformity, distal metatarsal articular angle (DMAA) hypercorrection, non-congruent first-ray metatarsophalangeal (MTP1) joint.

Statistical analysis

Multivariate analysis identified preoperative MTP1 joint mobility ($p < 10^{-4}$; estimate = 0.64; 95% confidence interval [CI], 0.48–0.81) and radiographic signs of MTP1 arthritis ($p = 0.02$) as independent predictors of postoperative MTP1 joint mobility. Preoperative MTP1 arthritis was associated with a significant loss of dorsiflexion of 10% compared to arthritis-free patients ($p = 0.02$). Preoperative M1P1 angle was the sole predictor of postoperative M1P1 angle (estimate = 0.29; 95% CI: 0.18–0.41; $p < 10^{-4}$). Mean metatarsophalangeal valgus correction was 50% of the preoperative deformity. Multivariate analysis found that associated lateral ray surgery significantly impacted postoperative DMAA: in case of lateral ray metatarsal osteotomy, mean postoperative DMAA was 4° less than in case of isolated first-ray surgery ($p < 0.001$). Multivariate analysis identified lateral metatarsal surgery as a predictor of postoperative MTP1 congruency, with a 17% risk of postoperative incongruency in case of isolated first-ray surgery and a 47% risk in case of associated lateral metatarsal osteotomy ($p = 0.009$; odds ratio: 0.24) (Fig. 7a and b).

Discussion

In the present series, percutaneous correction of mild-to-moderate hallux valgus by Reverdin-Isham osteotomy provided significant functional improvement, comparable to results from other percutaneous first-ray distal metatarsal osteotomy procedures, with or without osteosynthesis [6,11,12,14,21–23]. Clinical results for percutaneous correction of hallux valgus are comparable to those of the main

Table 3 Comparison of techniques: clinical results.

Author (ref)	Date	Technique	Number of patients	FU (months)	Satisfaction (%)	Preoperative AOFAS score	Postoperative AOFAS score
Veri et al. [34]	2001	Proximal	37	12.2 years	90	37	92
Plaweski et al. [46]	1998	Scarf	120	3 years	85		
Bonnel et al. [54]	1999	Scarf	79	7			
Jardé et al. [43]	1999	Scarf	50	3.7 years	86		
Crevoisier et al. [42]	2001	Scarf	84	22	89.3		82
Salmeron et al. [52]	2001	Scarf	19	15			
Kristen et al. [28]	2002	Scarf	111	3 years		50.1	91
Freslon et al. [35]	2005	Scarf	123	4.8 years	84.6		
Aminian et al. [24]	2006	Scarf	27	16.1		54.5	86.5
Skotak and Behounek [49]	2006	Scarf	62	18			
Chou et al. [25]	1998	Chevron	17	33			91
Trnka et al. [33]	2000	Chevron	57	5 years	87	59.2	91
Teli et al. [52]	2001	Chevron	60	25			83.2
Strienstra et al. [32]	2002	Chevron	38	31			93.5
Schneider et al. [31]	2004	Chevron	112	12.7 years		46.5	88.8
Weinberger et al. [48]	1991	Distal	301	8.3	87.55		
Magnan et al. [11]	2005	Distal	118	3 years	91		88.2
Bauer et al. [23]	2009	Distal	189	12	87	52	93
Present series	2009	Distal	104	2 years	89	49	87.5

conventional open surgery procedures, such as chevron, Scarf or proximal metatarsal osteotomy, where postoperative AOFAS scores range from 82 to 93.5, depending on the reports (Table 3) [24–34]. Patient expectations focus on pain, footwear tolerance and walking [35–40]. Percutaneous Reverdin-Isham osteotomy would thus seem to be as effective as the main conventional procedures, providing both significant functional improvement on all criteria (pain, function, alignment) and a high-level of patient satisfaction [10–13,21,25,26,33–35,41–48].

Unlike Kadakia et al., who reported unacceptable rates of early complication following percutaneous distal metatarsal osteotomy, the present series showed no non-union, osteonecrosis or early recurrence [15]. It should nevertheless be stressed that the percutaneous technique involves a non-negligible learning curve to achieve reproducibility, avoiding soft-tissue trauma, and that the postoperative dressing protocol and rigorous follow-up over the first months are mandatory.

MTP1 joint stiffness

MTP1 joint stiffness is one of the most feared complications of hallux valgus correction surgery. Moderate stiffness with about 10–20% loss of mobility is generally reported for open hallux valgus surgery [10,31,33,41,49]. Medial MTP1 capsule plasty induces immediate joint amplitude loss, first

impairing dorsiflexion [50]. Severe MTP1 joint stiffening with significant functional impact is relatively rare, and often the result of complications such as infection, delayed consolidation or complex regional pain syndrome [11,33,35,47]. Fibrosis and MTP1 joint capsuloligamentary retraction following extensive resection are considered to be the main causes of stiffness secondary to open correction. Percutaneous techniques theoretically reduce the risk of stiffness, due to the limited approach, and in case of extra-articular metatarsal osteotomy [6,11,48]. Percutaneous Reverdin-Isham osteotomy may, however, induce stiffness, due to the extensive medial resection of the metatarsal head, the release of bone debris in the joint space and capsule and the intracapsular osteotomy involved [12,13]. With a median 15° loss of MTP1 joint mobility, stiffness secondary to percutaneous Reverdin-Isham osteotomy is comparable to that induced by other percutaneous or open surgery techniques [31,33,49]. The need for abundant lavage of the work-space, however, should be stressed, to clear bone debris liable to cause an inflammatory reaction, with fibrosis and stiffening.

Radiographic results

This percutaneous procedure proved effective in correcting mild-to-moderate deformity, achieving a median postoperative MTP1 angle of 15°. Such a 50° angular correction is comparable to that reported with other per-

Table 4 Comparison of techniques: radiologic results.

Author (ref)	Year	Technique	Preoperative M1P1 angle	Postoperative M1P1 angle	Preoperative M1M2 angle	Postoperative M1M2 angle	Preoperative DMAA	Postoperative DMAA
Veri et al. [34]	2001	Proximal	37	13	16	6		
Plaweski et al. [46]	1998	Scarf	28	18	14	10		
Bonnel et al. [54]	1999	Scarf	31.3	9	11.4	6.2	14.6	12.6
Jardé et al. [43]	1999	Scarf	39.8	22.7	15	10.4		
Crevoisier et al. [42]	2001	Scarf	32	17	16	10	13	10
Salmeron et al. [52]	2001	Scarf	28	17	11.5	8.2	13	11
Kristen et al. [28]	2002	Scarf		19.1		6.6		
Freslon et al. [35]	2005	Scarf	31.2	17.5	12.1	7.5		
Aminian et al. [24]	2006	Scarf	34.5	16.9	15.4	10.1		
Skotak and Behounek [49]	2006	Scarf	37	18	16	9		
Chou et al. [25]	1998	Chevron	22	18	11	9	16	9
Trnka et al. [33]	2000	Chevron	29	18	13	9		
Teli et al. [52]	2001	Chevron	31.7	16.9	15.4	8.6	11.3	7.1
Strienstra et al. [32]	2002	Chevron	29.4	11.4	15	4.8		
Schneider et al. [31]	2004	Chevron	27.6	14	13.8	8.7		
Weinberger et al. [48]	1991	Distal	26	7.5			12.6	6.6
Magnan et al. [11]	2005	Distal	31.5	13.7	12.3	7.3	14.2	6.7
Bauer et al. [23]	2009	Distal	28	14	13	10	15	8
Present series	2009	Distal	30	15	14	11	15	7

cutaneous or open distal metatarsal osteotomy techniques [6,11,13,23,31–33,51,52] or with Scarf osteotomy (Table 4) [24,27,28,30,35,42,49,53–55]. Weinberger et al. reported better angular correction with a different percutaneous metatarsal osteotomy, with M1P1 angle reduced from 26 to 7.5° [48]. With a mean 50% M1P1 angle correction and slight impact on the M1M2 angle, percutaneous Reverdin-Isham osteotomy is adapted and effective for the correction of mild-to-moderate deformities (M1M2 angle $\leq 15^\circ$, and M1P1 angle about 30°).

One of the aims of Reverdin-Isham osteotomy is to reduce the DMAA by medial rotation of the first-metatarsal head. In the present series, the mean reduction in DMAA was 50% (median DMAA = 15° preoperatively vs. 7° postoperatively). Comparable DMAA correction was reported by Magnan et al. for the same type of percutaneous procedure [23], with percutaneous distal metatarsal osteotomy [11,14] and by Chou et al. [25] for chevron osteotomy. Coughlin and Carlson reported better DMAA correction (from 23 to 9°) with double metatarsal osteotomy [26]. With Scarf osteotomy, medial rotation of the plantar metatarsal fragment seems more limited, but still possible using certain tricks to obtain several degrees of DMAA correction [28,35,42,53,54]. The present series featured wide variation in DMAA, with a range of 17° preoperatively and a range of 20° postoperatively. This confirms that DMAA measurements lack precision and reproducibility, due both to the X-ray views (X-ray orientation) and to first-metatarsal rotation in case of severe metatarsus varus [41,56–60]. In moderate first-ray deformity, there is less first-metatarsal rotation, making DMAA measurement theoretically more reliable. The wide variation in postoperative DMAA values, however, shows that this percutaneous correction technique fails to ensure reliably precise and foreseeable DMAA reduction [48]. This imprecise adjustment of first-metatarsal head medial rotation, which may be due to technical error or to bone quality (excessive impaction in case of osteoporosis), can induce hypocorrection of the DMAA, with a risk of recurrence of valgus deformity, or hypercorrection, with a risk of postoperative MTP1 joint non-congruency. The main limit of Reverdin-Isham osteotomy emerging from the present series was lack of stability in case of associated lateral ray surgery, with a significant 4° hypercorrection of the DMAA and significantly elevated risk of postoperative MTP1 joint non-congruency (17% for isolated first-ray surgery, and 47% in case of associated lateral ray surgery). It is as though the displacement induced by the lateral ray osteotomies (shortening and elevation of the metatarsal heads) increased stress on the Reverdin-Isham osteotomy, jeopardizing stability (with risk of DMAA hypercorrection du DMAA and MTP1 joint non-congruency). The present study indicates that Reverdin-Isham osteotomy is a reliable technique for the correction of isolated medium-to-moderate hallux valgus without significant metatarsus varus (M1M2 angle $\leq 15^\circ$), with elevated DMAA and congruent MTP1 joint.

Study limitations

The present study involves certain limitations, and notably a mean follow-up of no more than 2 years. Longer-term assessment will be required to confirm the present findings, both

clinically and in terms of angular correction. Bias may also have been induced by the fact that the clinical and radiological measurements were not made by an independent assessor.

Conclusion

Percutaneous correction of mild-to-moderate hallux valgus by Reverdin-Isham osteotomy provided clinical results that were comparable to those of most minimally invasive or conventional procedures, with 89% of patients satisfied or very satisfied at 2 years' follow-up. The technique does, however, involve a steep and long learning curve, and lacks precision in case of associated lateral metatarsal osteotomies, with a risk of DMAA hypercorrection and an elevated risk of MTP1 joint non-congruency. The optimal indications for correction of hallux valgus by percutaneous Reverdin-Isham osteotomy thus seem to be restricted to isolated (without lateral metatarsal procedure) mild-to-moderate hallux valgus (M1M2 angle $\leq 15^\circ$, and M1P1 angle about 30°), with elevated DMAA and good MTP1 congruency. In case of associated lateral metatarsal procedure (percutaneous distal osteotomy), another first-ray technique should be used: conventional (Scarf, chevron), or minimally invasive or percutaneous chevron osteotomy, with or without fixation. Further studies of percutaneous hallux valgus correction techniques are needed, to refine indications and assess long-term stability and patient benefit in terms of resumption of footwear and activity.

Conflict of interest

None.

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